SELECTION OF SUITABLE TECHNOLOGY FOR SEWAGE TREATMENT BASED ON LIFE CYCLE COST (LCC) & DECISION SUPPORT SYSTEM (DSS)

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TECHNOLOGY OPTIONS FOR STP'S

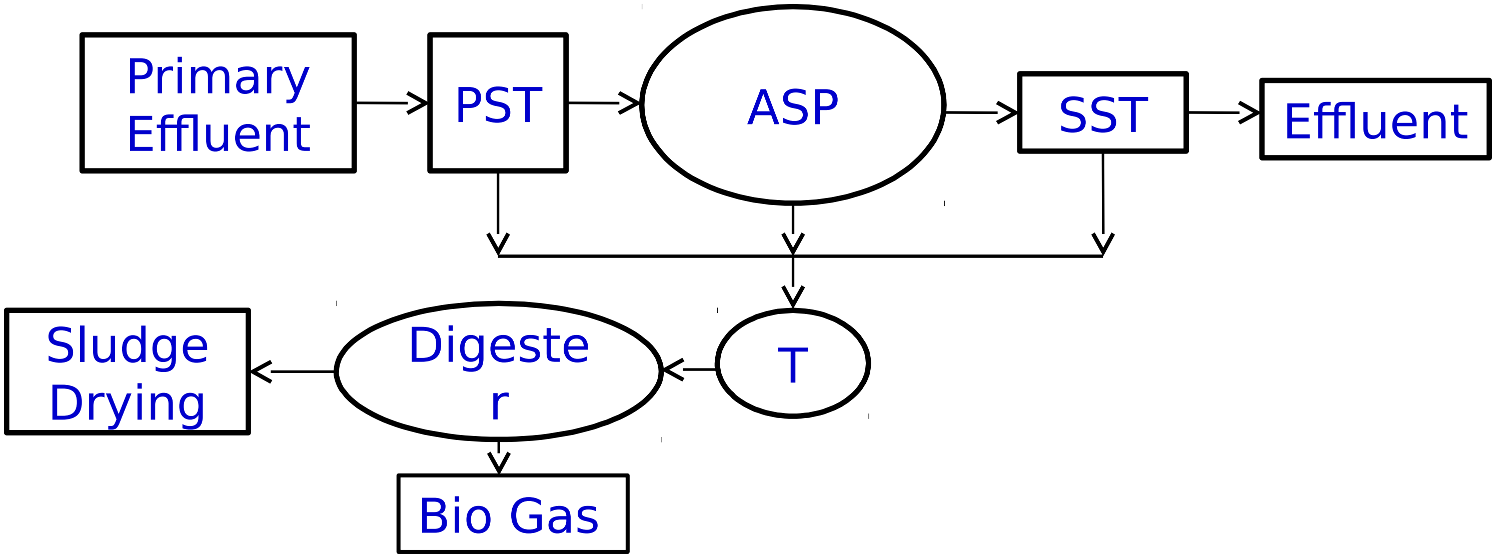
- Comprehensive analysis of performance and Life Cycle Cost (LCC) analysis from a large number of sewage treatment plants in the **Ganga river basin and Musi river basin** and elsewhere employing all the technological options are :

1	ASP	**6**	Two stage Trickling filter
2	UASB	**7**	Waste Stabilization ponds (WSPs)
3	Moving Bed Biological Reactors (MBBRs)	**8**	Biological Filtration and Oxygenated Reactor (BIOFOR)
4	Membrane Bio Reactor (MBR)	**9**	Submerged Aeration Fixed Film Technology
5	Sequential Batch Reactors (SBRs)	**10**	Duckweed Pond System

WASTEWATER CHARACTERISTICS

S.No.	Parameters	Influent characteristics	Effluent Characteristics
1	**pH**	7.0—9.0	7.0—9.0
2	**BOD 5 days @ 20°C**	250 mg/l	< 20 mg/l
3	**COD**	450 mg/l	<100 mg/l
4	**TSS**	300 mg/l	<10 mg/l
5	**Total Kjeldal Nitrogen (as N)**	15mg/l	<10mg/l
6	**Ammonia Nitrogen (as N)**	10 mg/l	<2mg/l
7	**Total Phosphorus (as PO_4)**	5 mg/l	<2mg/l
8	**Fecal Coliform**	$1*10^6$ Nos/100ml	200 Nos/100ml
9	**Total Coliform**	$1*10^7$ Nos/100ml	--- Nos/100ml
10	**Oil & Grease**	15 mg/l	<5mg/l

ACTIVATED SLUDGE PROCESS (ASP)



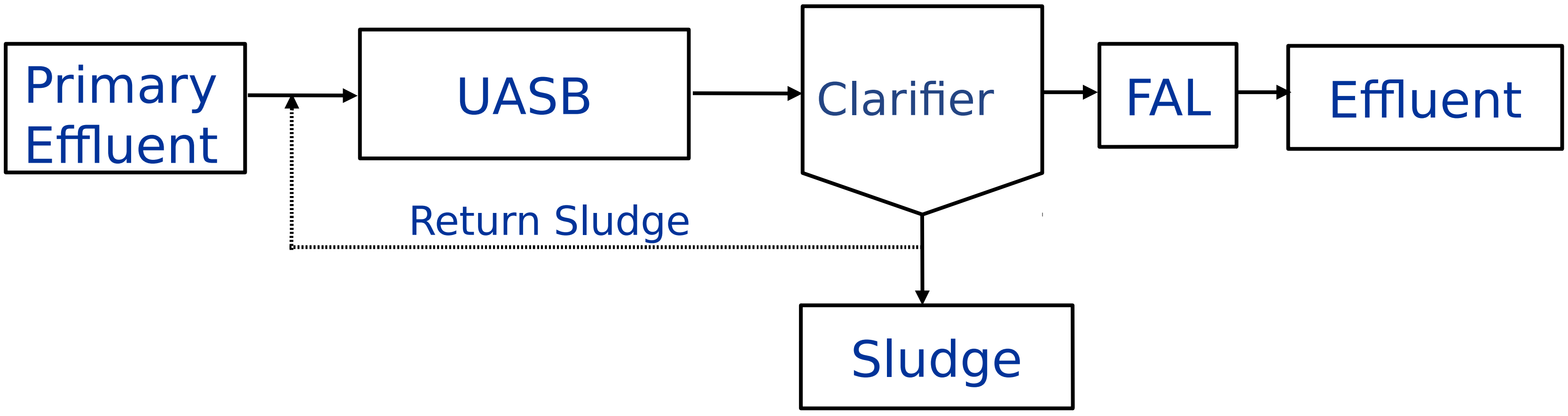
Capital cost : Rs. **2-4** million per MLD; **55 %** Civil works and **45 %** Electrical

O & M Costs : Rs. **0.3 - 0.5** million/year/MLD installed Capacity

Land Requirement :**0.15 - 0.25** hectares/MLD installed capacity

Energy Requirement : **180 - 225** KWh/ML treated

UASB



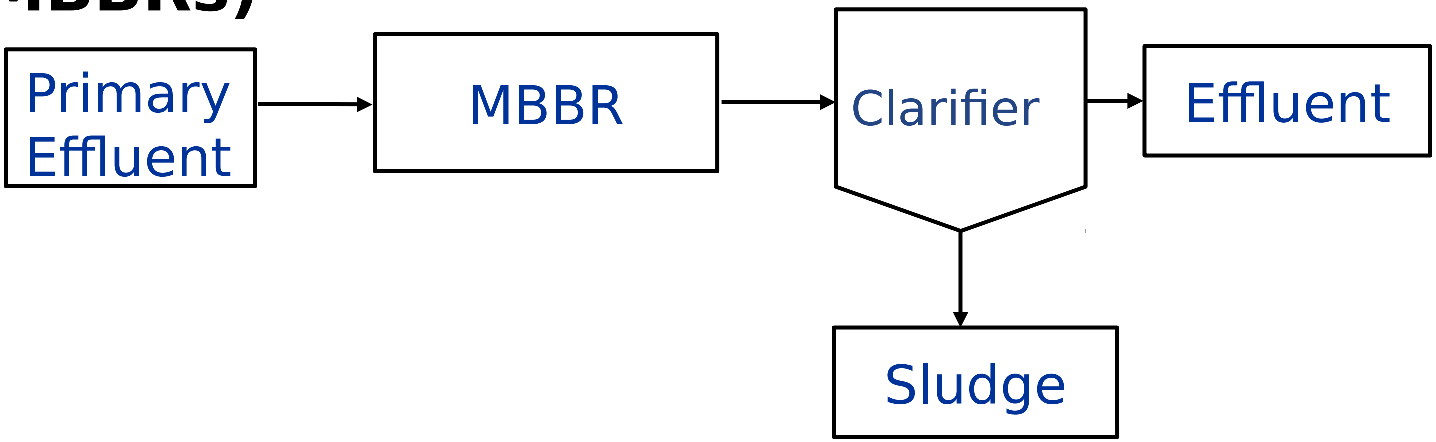
Capital cost : Rs. **2.5 - 3.6** million per MLD

O & M Costs : Rs. **0.08 - 0.17** million/year/MLD installed capacity

Land Requirement :**0.2 - 0.3** hectares/MLD installed Capacity

Energy Requirement : **10 - 15** KWh/ML treated

Moving Bed Biological Reactors (MBBRs)



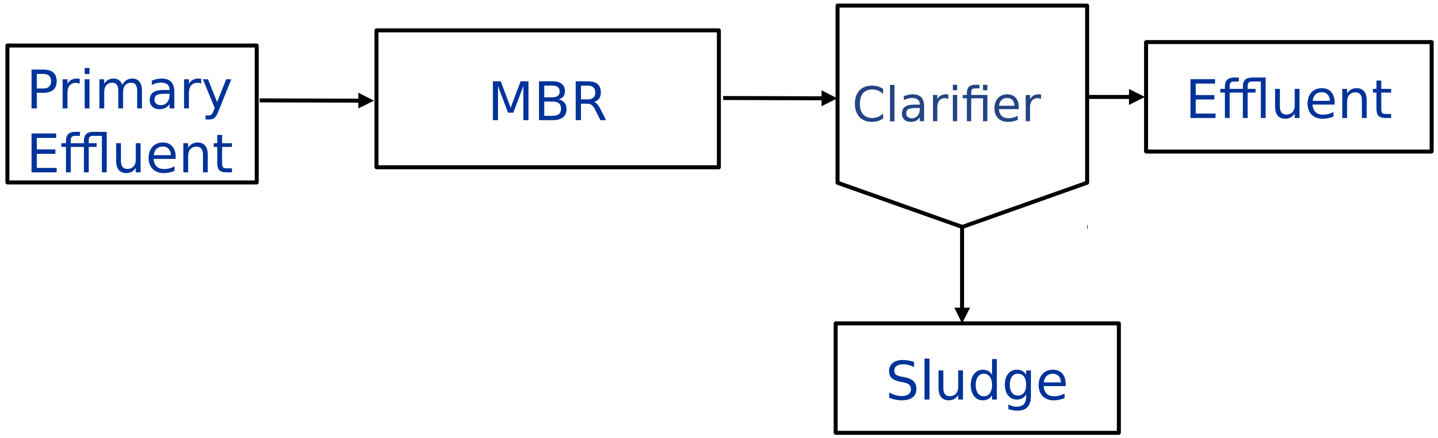
Capital cost : Rs. **3.0 - 5.0** million per MLD

O & M Costs : Rs. **0.6 - 0.75** million/year/MLD installed capacity, about 50% higher than ASP.

Land Requirement :**0.06** hectares/MLD installed Capacity

Energy Requirement : **99 - 170** KWh/ML treated

MEMBRANE BIO-REACTOR (MBR)



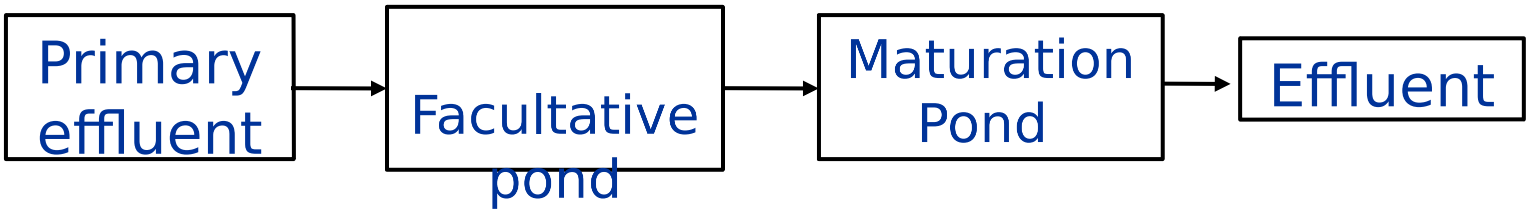
Capital cost : Rs. **30.0 - 40.0** million per MLD

O & M Costs : Rs. **2.0 – 3.0** million/year/MLD installed capacity, about 40% higher than ASP.

Land Requirement :**0.04** hectares/MLD installed Capacity

Energy Requirement : **700 - 1000** KWh/ML treated

WASTE STABILISATION PONDS (WSPS)



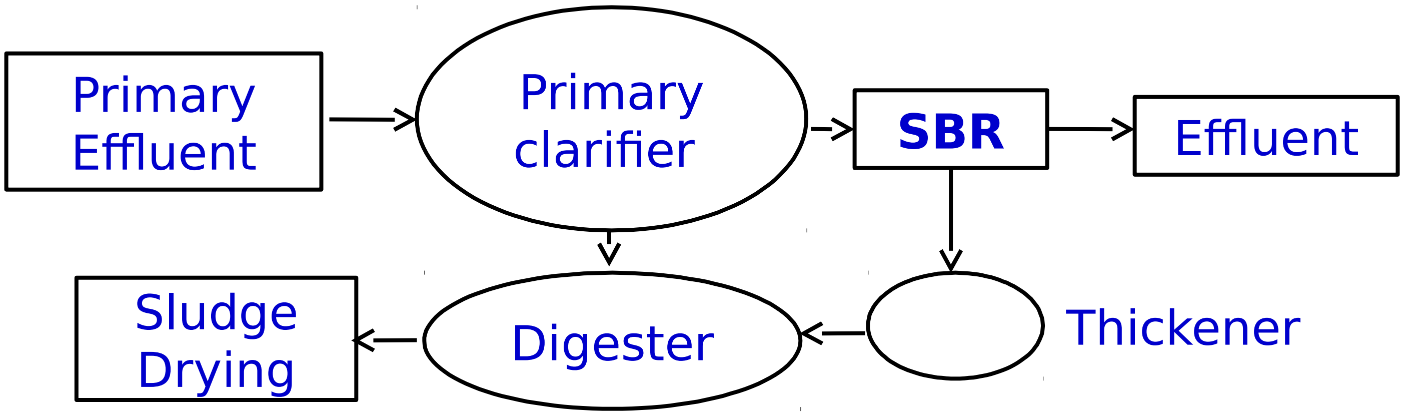
Capital cost : Rs. **1.5 - 4.5** million per MLD

O & M Costs : Rs. **0.06 – 0.1** million/year/MLD installed capacity, about 40% higher than ASP.

Land Requirement :**0.8-2.3** hectares/MLD installed Capacity, 3 - 4 times the land requirement for ASP

Energy Requirement : **0.5 - 5** KWh/MLD

SEQUENTIAL BATCH REACTORS (SBRS)



Capital cost : Rs. **30.0 - 40.0** million per MLD

O & M Costs : Rs. **0.8 – 0.9** million/year/MLD installed capacity, about 40% higher than ASP.

Land Requirement :**0.05** hectares/MLD installed Capacity

Energy Requirement : **170 - 180** KWh/ML treated

Comparative merits and demerits of each technology

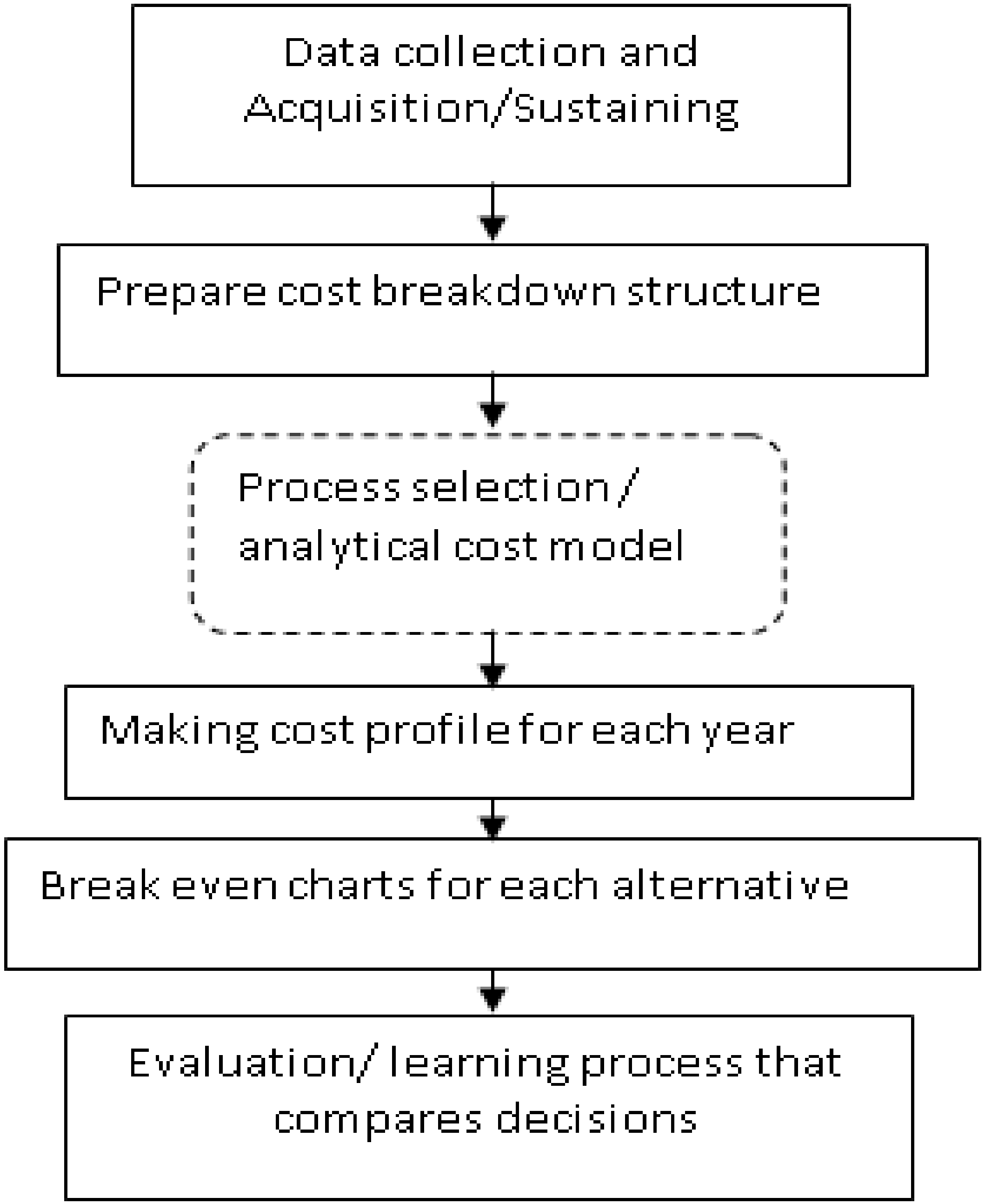
S.No.	Category	Capital Cost Million/ MLD (Rs)	O & M Costs Million/year/ MLD (Rs)	Land Requirement Hectares/ MLD	Energy Requirement KWh/ML	Merits	Demerits
1	ASP	2-4	0.3 - 0.5	0.15 - 0.25	180 - 225	Moderate land required , well proven technology	High energy consumption, Adversely effected with in a short period
2	UASB	2.5 - 3.6	0.08-0.17	0.2-0.3	10 - 15	Less sludge production, high hydraulic and organic shock loading , no additional power required	Stability in performance is questionable, fecal and total coliform removal is poor
3	MBBRs	3-5	0.6-0.75	0.06	99 to 170	Less land requirement	High initial cost, patented filter media
4	MBR	30-40	2.0-3.0	0.04	700 to 1000	High quality effluent, Less land requirement	High initial & operating cost, high energy required
5	WSP	1.5 - 4.5	0.06-0.1	0.80 - 2.3	Negligible	Power required is negligible	More land is required, odour nuisance & mosquito breeding
6	SBR	30-40	0.8-0.9	0.05	170-180	Low capital & operating cost , simplicity in design, installation & operation	Required skilled operation & maintenance , proprietary process & design details are not available

DECISION SUPPORT SYSTEM (DSS)

The Decision Support System helps to select the best technology at the specific location. The main components considered for this exercise for various alternative technologies

- Land Issues
- Technology acceptance and O & M issues
- Life cycle cost
- Aquatic ecology
- Reuse & recycle options
- Local attributes

DSS is flexible enough to account for the users preferences.


Data collection and Acquisition/Sustaining
Prepare cost breakdown structure
Process selection / analytical cost model
Making cost profile for each year
Break even charts for each alternative
Evaluation/ learning process that compares decisions

The weightage percentage of the components

S.No.	Selection criteria / group	Weighted Percentage
1	Life Cycle Cost (LCC)	45
2	Technology acceptance and O&M issues	10
3	Land	10
4	Reuse & Recycle	10
5	GHGs	10
6	Local Attributes	10
7	River Ecology	5
	Total	100

Impact score instrument

S.no	Description	Points
Category-1	Best acquirable/ Best suitable & feasible options /Positive impacts. (Land availability is not at all a problem, very good weather conditions, technologies with very good performances & easily operatable, best opportunity for Recycle & Reuse, less GHG emissions, positive impacts on river ecology, best feasible LCA)	**10**
Category-2	Acquirable with some efforts/ fairly suitable & feasible options /No adverse impacts. (Land is available and can be acquired with some efforts, fair weather conditions, technologies with good performances & operatable, fair opportunity for Recycle & Reuse, fair GHG emissions, positive impacts on river ecology, favorable local attributes, fairly feasible LCA).	**9-6**
Category-3	Acquirable with high efforts/ suitable & feasible options to some extent /Negligible impact. (low impact & low probability of occurrence) (Land is available and can be acquired with high efforts, moderate weather conditions, technologies with limited performances & operatable, less opportunity for Recycle & Reuse, moderate GHG emissions, negligible impacts on river ecology, better	**5-1**

Category-4	Land availability is a concern, performances of the technologies are a concern, remote chances of recycled & reuse options, adverse GHG emissions, adverse local attributes, minor ecological impacts. (Land can be acquired from a private owner with a separate R&R Package, Performance & operations are an issue, remote chances of recycle & reuse options, adverse GHG emissions, adverse local attributes, Minor ecological impacts, average local attributes, slight higher LCA costs)	(-)1 to (-)
Category -5	Land availability is a major concern, unacceptable performances of technologies, recycle & reuse options is not possible at present, adverse GHG emissions, adverse local attributes, moderate ecological impacts. (Land can be acquired from a private owner with a separate R&R Package with great effort, Performance & operations are an issue, recycle & reuse options is not possible at present, adverse GHG emissions, adverse local attributes, Minor ecological impacts, bad local attributes, moderate higher LCA costs)	(-)4 to (-)6
Category -6	Land availability is not possible, performances of technologies is worst, recycle & reuse options are ruled out, higher GHG emissions worst local attributes, major ecological impacts. (The land can't be acquired, Performance & operations are worst, recycle & reuse	(-)7 to (-)10

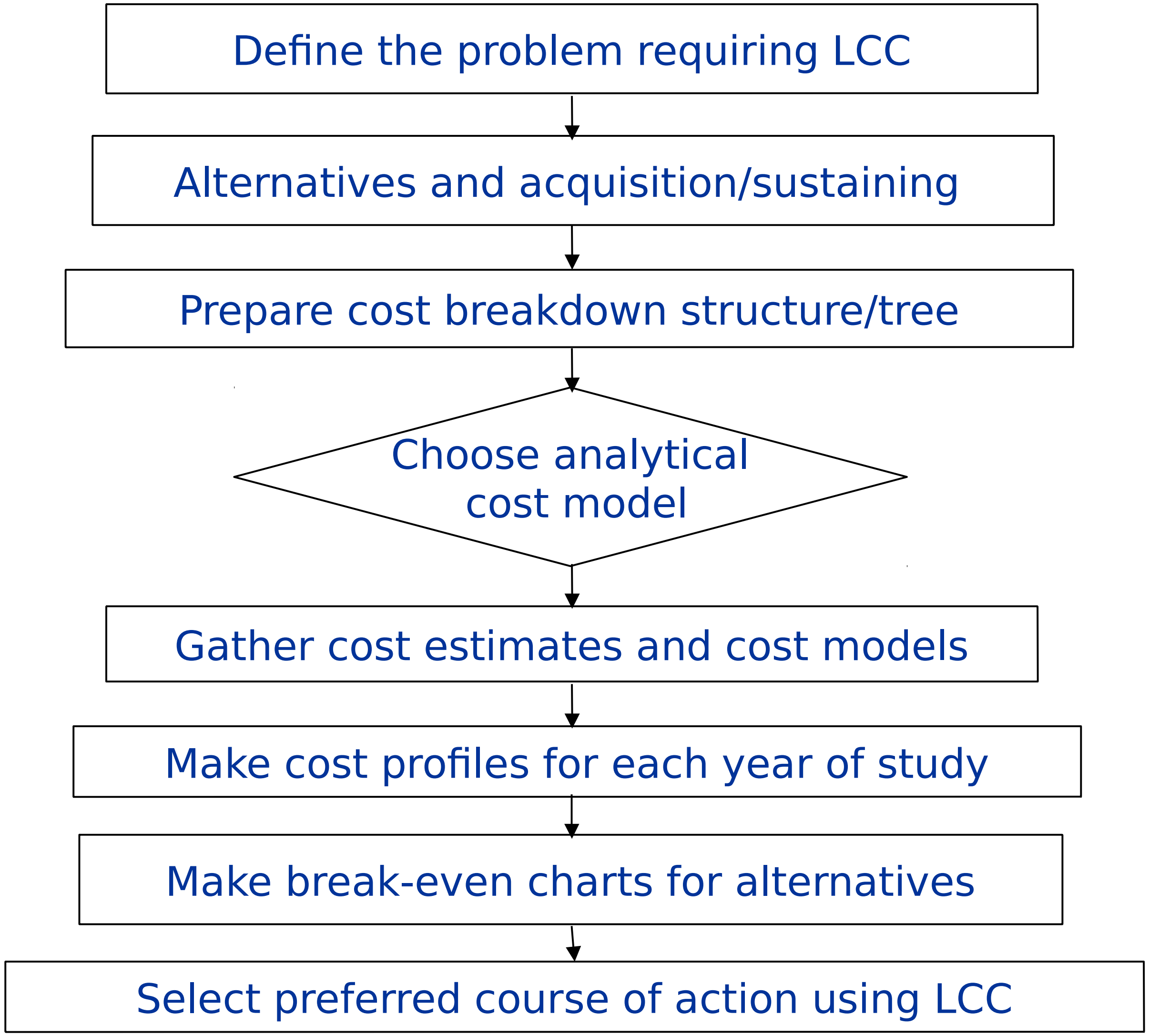
LIFE CYCLE COST (LCC)

- **LCC is an economic model over the project life span, evaluating alternatives for equipment and projects**

Concept : Cradle to Grave concept

Objective: To choose the most cost effective system for the series of alternatives

STEPS IN LCC


Define the problem requiring LCC
Alternatives and acquisition/sustaining
Prepare cost breakdown structure/tree
Choose analytical cost model
Gather cost estimates and cost models
Make cost profiles for each year of study
Make break-even charts for alternatives
Select preferred course of action using LCC

LCC....

Life Cycle Cost = Initial capital cost +NPV of O&M cost + Equipment replacement cost - (Depreciation cost + Present worth of salvage value

i) **Initial cost** = Civil cost + Equipment + land cost (30 years)

ii) **NPV of O&M cost** = 29.96 x net operating cost

iii) **Equipment replacement cost** = 15% of equipment cost

iv) **Depreciation cost** = 0.0889 x cost of civil works

v) **Present worth salvage value** = 20 % of equipment cost

resent worth of salvage value)

The discounting factor for operation and maintenance for 30 years LCC is 29.96, is evaluated using the Equation below Discounting factor

$$(DF_{O\&M}) = C \times (1+i)^{-j}$$

Where "C" is the present value of the money, and "*i*" is the interest rate, "*j*" is the number of years in the future.

The depreciation factor is evaluated using the Equation from (Sato et al., 2007).

$$DF = \frac{i\,(1+i)^{t}}{(1+i)^{t} - 1}$$

where "*i*" is the interest rate and "t" is the economic life

The salvage value (S) is the net worth in the final year of the life-cycle period and it is assigned a salvage value of 20% of the original cost of mechanical equipment that can be moved.

Depreciation cost = 0.0889 * costs of civil works

Present worth salvage value = 20% of the equipment cost (present wroth of

salvage value

- **LCC & DSS Analysis**
- **SUMMARY OF RECOMMENDATIONS**

Alternatives Evaluation Through STP Decision Support System for Waste Water Treatment Plants

S.NO.	Attributes	Importance weighs (Set by the user)	UASB process+ Extended Aeration (1)	Weighted component	ASP-EA , Extended Aeration	Weighted component	Moving Bed Bio-reactor (MBBR)	Weighted component	Membrane Bio Reactor (MBR)	Weighted component	Sequential Batch Reactor Process (SBR)	Weighted component
1	Land	15	60.0	900.0	60.0	900.0	74.3	1114.3	74.3	1114.3	77.1	1157.1
2	Technology Acceptance and O&M issues	15	84.3	1264.3	82.9	1242.9	62.9	942.9	60.0	900.0	67.1	1007.1
3	Life Cycle Analysis (LCA)	25	90.0	2250.0	70.0	1750.0	50.0	1250.0	50.0	1250.0	70.0	1750.0
4	River Ecology	20	76.7	1533.3	76.7	1533.3	80.0	1600.0	70.0	1400.0	83.3	1666.7
5	Reuse and Recycle	15	53.3	800.0	53.3	800.0	53.3	800.0	76.7	1150.0	53.3	800.0
6	Local Attributes	10	23.3	233.3	3.3	33.3	3.3	33.3	3.3	33.3	20.0	200.0
	Weighted percentages	100		69.81		62.60		57.40		58.48		65.81

Recommended Alternative: MBBR

Thank you